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(56) Publications considered for determining the patentability:

DE-PS 6 57 136

DE 28 55 561

CH 5 65 941

US 23 87 560

(54) **Supercharged internal combustion engine having an exhaust-gas driven supercharger group**

A partial disengagement of supercharger group (12) takes place in the partial load operation of internal combustion engine (11) in order to achieve a charging air supply optimally matched with the load conditions of internal combustion engine (11). The partial disengagement is achieved on the drive side of supercharger group (12) by a partial admission of exhaust gas to two-stage exhaust gas turbine (15) matched to the exhaust gas supply. On the air feed side of supercharger group (12), partial admission is achieved by matching the power input of the two supercharger air compressors (16, 17) constantly in drive connection with the exhaust gas turbine (15) by connecting, disconnecting, and changing-over different air lines.

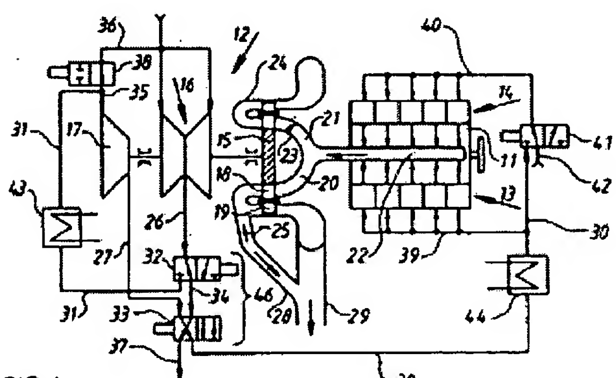

FIG. 1

(19) BUNDESREPUBLIK DEUTSCHLAND

DEUTSCHES PATENTAMT

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(56) Für die Beurteilung der Patentfähigkeit in Betracht gezogene Druckschriften:

DE-PS	6 57 136
DE	28 55 551
CH	5 65 941
US	23 87 560

(54) Aufgeladene Brennkraftmaschine mit einer abgasbetriebenen Aufladegruppe

Im Teillastbetrieb der Brennkraftmaschine (11) erfolgt eine Teilabschaltung der Aufladegruppe (12) um bei vermindertem Abgasangebot eine an die Lastzustände der Brennkraftmaschine (11) optimal angepaßte Ladeluftversorgung zu erreichen. Die Teilabschaltung wird auf der Antriebsseite der Aufladegruppe (12) durch eine dem Abgasangebot angepaßte Teilbeaufschlagung der zweitstufigen Abgasturbine (15) erreicht. Auf der Luftförderseite der Aufladegruppe (12) wird die Teilabschaltung über eine Anpassung der Leistungsaufnahme der ständig mit der Abgasturbine (15) in Antriebsverbindung stehenden beiden Ladeluftverdichter (16, 17) durch Zu-, Ab- und Umschalten verschiedener Luftleitungen realisiert.

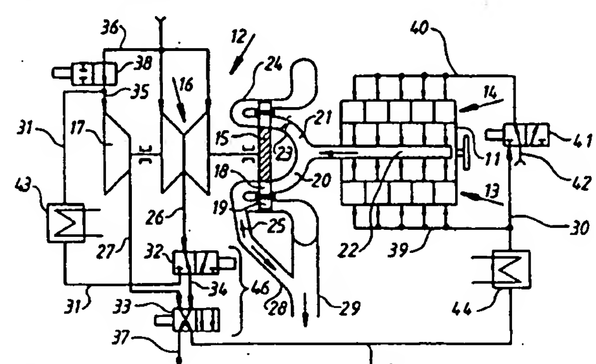

FIG. 1

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F02C 6/12 , F02B 37/00 , F04D 25/02 25/16

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F1G GPA GPC
F1C CBE C104 C602
U1S S1994

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EP 0620363 A1 EP 0555948 A1 EP 0440902 A1
WPI Abstract Accession No. N92-279667 of DE4113247

(58) Field of Search
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INT CL^6 F02B 37/00 37/007 37/013 , F02C 6/00 6/04 6/10 6/12 , F04D 25/00 25/02 25/04 25/08 25/16
ONLINE WPI

(54) Abstract Title
Turbocharger arrangement

(57) A turbocharger for a diesel engine, especially an engine rated at 10 MW or more, has a single turbine 10, in a housing 19, which drives a number of compressor impellers 31, of compressors 20,30,40,50 through a system of gearing 60, the impellers being driven not on the same shaft as the turbine, but on separate shafts. The gearing arrangement may take various forms (figs. 2,3 and 5) and may also drive a hydraulic pump or electric motor/generator to supplement turbine power to the engine during certain periods of engine operation, and/or to absorb power from the turbine during other periods. A diffuser 15, axially in line with the turbine shaft and an axial exhaust outlet may be employed in conjunction with the turbocharger, this representing an optimised exhaust configuration. The compressors may act in parallel, series or series-parallel relationship to supply air to the engine.

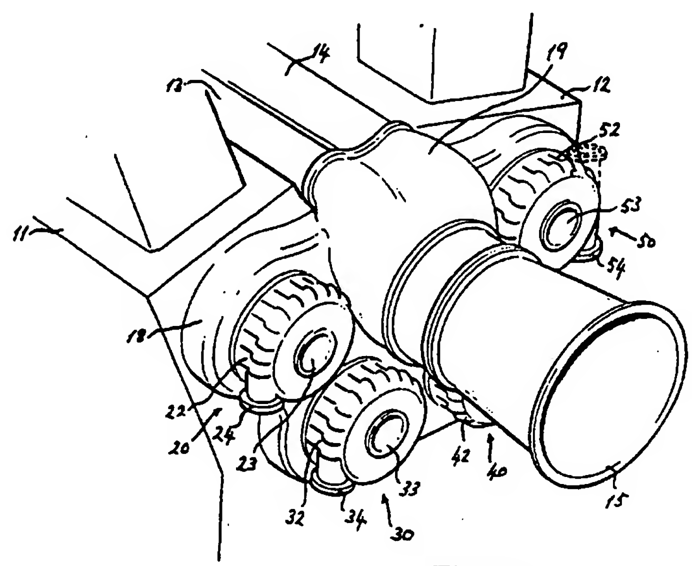

Figure 1

Figure 2

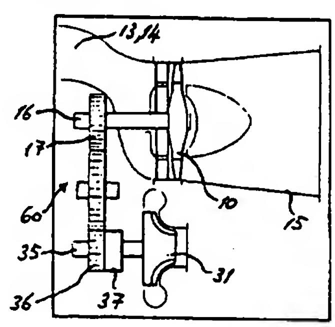

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Figure 2

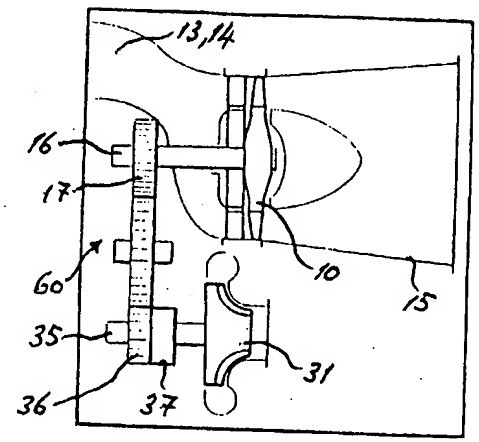
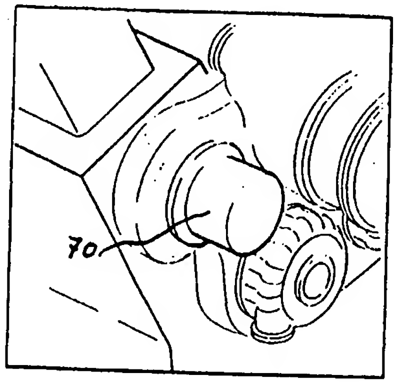


Figure 6



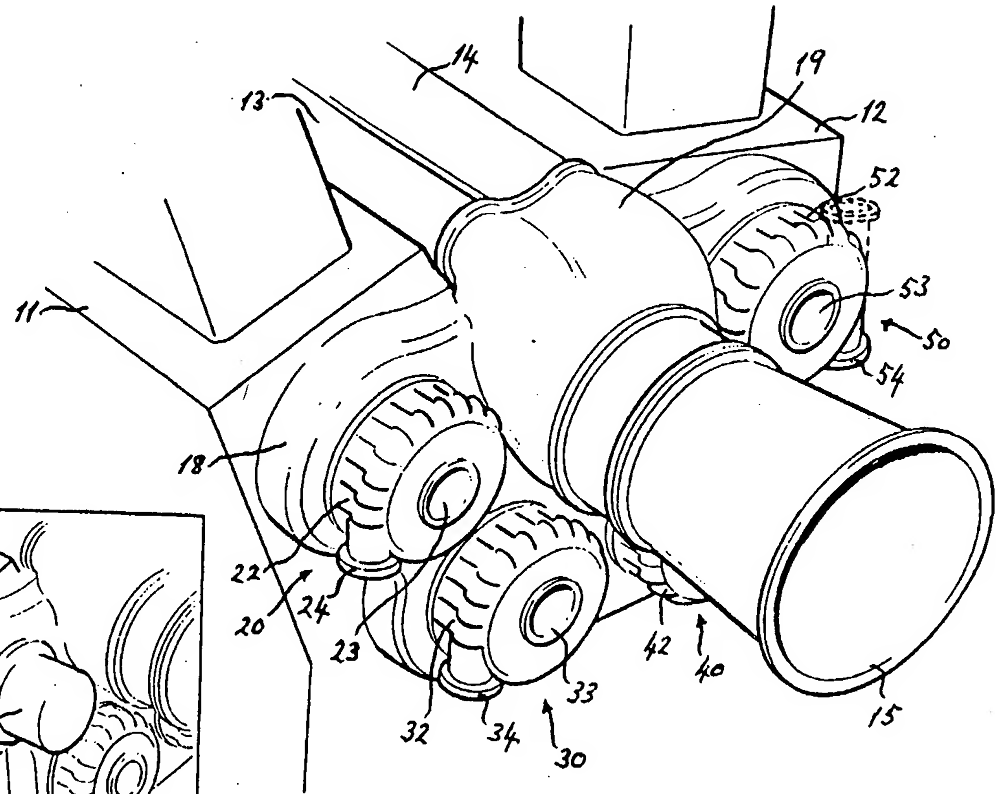


Figure 1

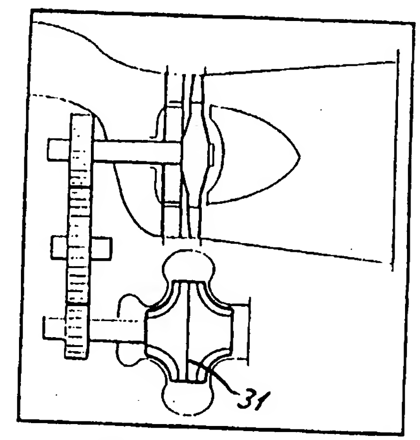
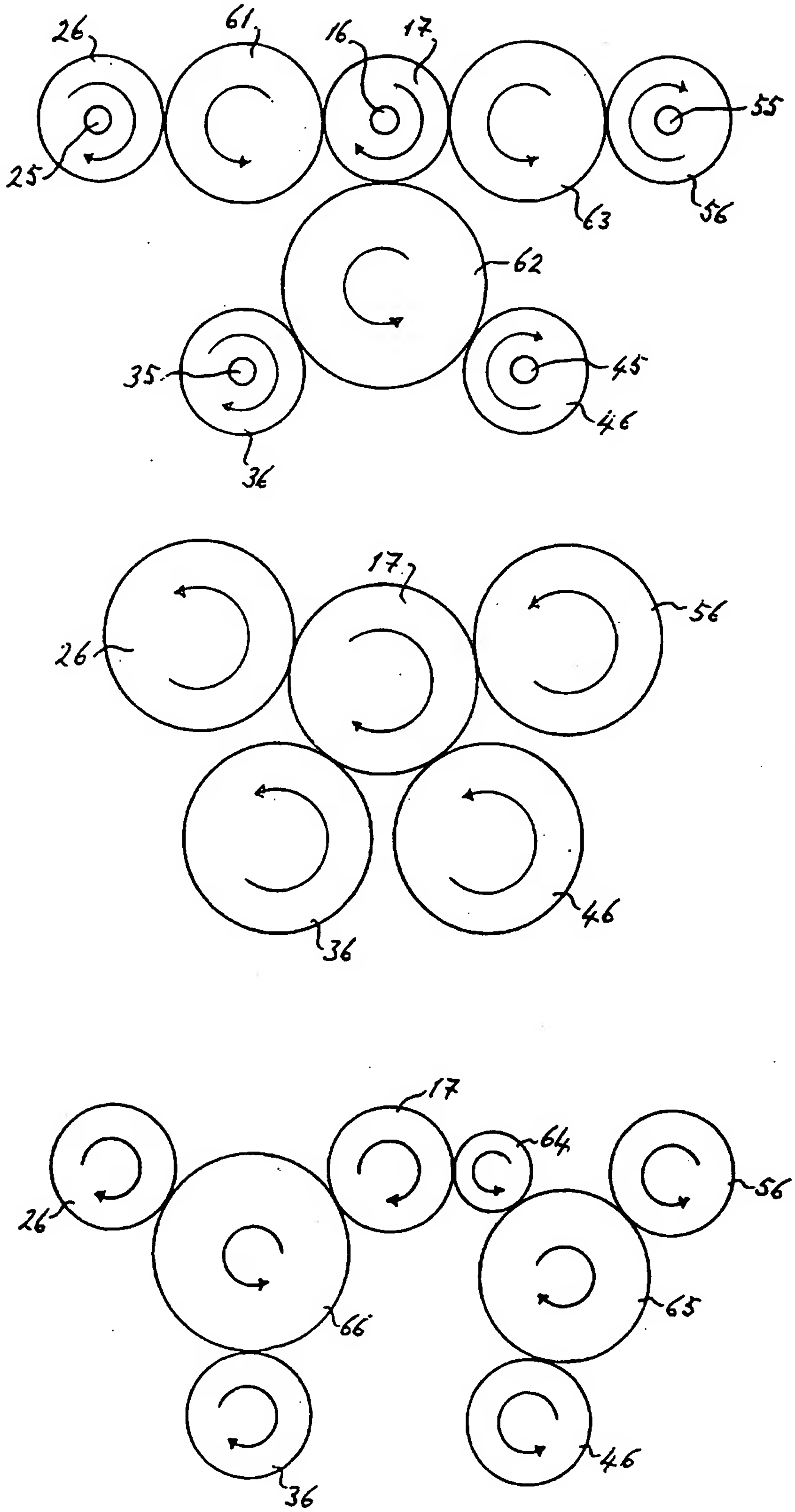


Figure 5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(a)

(b)

(c)

Figure 3

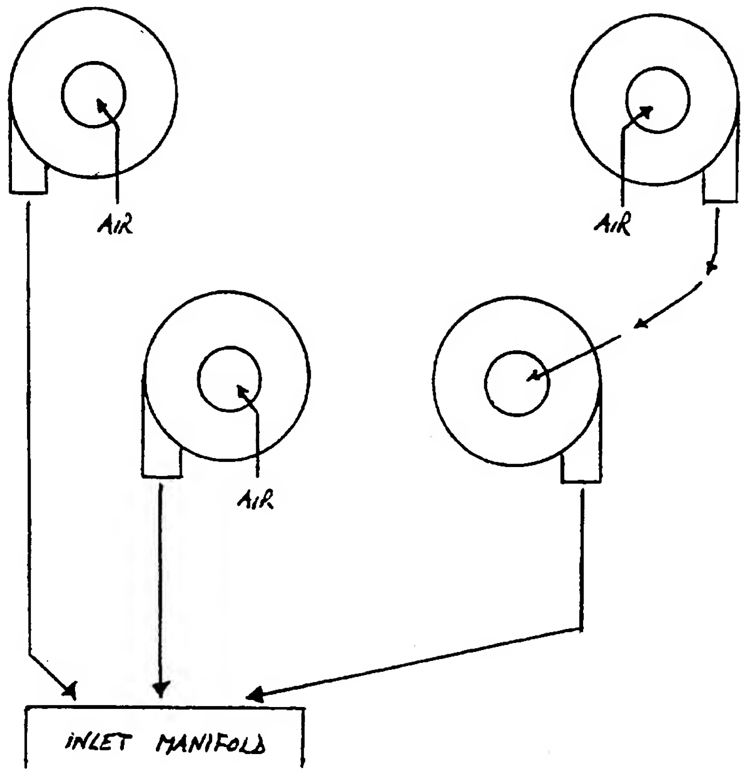

Figure 4

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TURBOCHARGER ARRANGEMENT

The invention concerns a turbocharger arrangement and in particular, but not exclusively, a turbocharger arrangement for a diesel engine, especially a diesel engine rated at 10 MW or higher.

Turbochargers are well known devices which utilise the energy resident in engine exhaust gas to boost the amount of charge air available to the engine. In a basic turbocharger design a turbine which is turned by the exhaust gas drives an impeller which supplies compressed air to an air inlet of the engine. Very often the turbine and the compressor impeller are mounted on a common shaft for the transfer of movement from one to the other.

It is evident that larger engines require larger turbochargers, however as the turbocharger becomes physically bigger and engine ratings rise, the demands placed on certain critical parts become considerable. In particular the loading and stress levels in the rotating impeller may require the use of very high grade materials, e.g. titanium, rather than the low-grade materials, e.g. aluminium, commonly used in smaller turbochargers and at lower engine ratings. Since the use of high-grade materials can add considerably to the cost of an engine, there is an incentive to reduce such use as far as possible.

In accordance with the invention there is provided a turbocharger arrangement comprising a turbine mounted on a turbine shaft having a first axis of rotation and a plurality of compressors mounted on respective compressor shafts having respective further axes of rotation, said first and further axes being separate axes, said turbine being in driving relationship to said compressors through an arrangement of gears.

The arrangement of gears may comprise for each compressor shaft a gear train connecting said compressor shaft with said turbine shaft. The gear train may comprise a driving pinion mounted on said turbine shaft, a driven pinion mounted on said compressor shaft, and at least one intermediate pinion connecting said driving pinion with said driven pinion. Alternatively, the intermediate pinions (idlers) may be omitted, the driven pinions then engaging directly with the driving pinion around its circumference.

The compressors may be connected in parallel, or in series, or in a series-parallel arrangement, to an air inlet of an engine with which the turbocharger is associated.

At least one of the compressors may be driven from said turbine by way of a disconnection means thereby to enable drive to said at least one of said compressors to be selectively disconnected in response to charge air requirements of said device.

A power source and/or sink may be brought into engagement with said arrangement of gears thereby to supplement power supplied by, and/or to absorb excess power from, said turbine. The power source and/or sink may be an hydraulic pump or a rotating electrical machine.

The turbine may be an axial-flow turbine and an exhaust-gas diffuser associated with said turbine may have a longitudinal axis substantially the same as said first axis of rotation, said diffuser in use discharging to an axial-flow exhaust outlet.

An embodiment of the invention will now be described, by way of example only, with reference to the drawings, of which:

Figure 1 is a general view of a turbocharger arrangement in accordance with the invention;

Figure 2 is a side view of a turbocharger arrangement in accordance with the invention;

Figure 3(a), (b) and (c) are end-on views of three ways of realising a gear linkage between turbine and compressor impellers in a turbocharger arrangement in accordance with the invention;

Figure 4 is a schematic diagram illustrating a series/parallel mode of connection of the compressor units of a turbocharger arrangement according to the invention to an engine air-inlet manifold;

Figure 5 is a side view of a turbocharger arrangement in accordance with the invention employing a "back-to-back" impeller arrangement, and

Figure 6 is a partial general view of a turbocharger arrangement according to the invention incorporating a supplementary power source/sink.

Referring first to Figures 1 and 2, a turbocharger arrangement according to the invention includes a turbine 10, contained within a turbine housing 19, driven from exhaust gases supplied to the turbine from engine cylinder heads 11, 12 along conduits 13 and 14. The exhaust gases are released to atmosphere along a diffuser 15 and an exhaust system (not shown) downstream of the turbocharger. Clustered around the turbine in an approximate semicircle are four compressor units 20, 30, 40, 50 each comprising an impeller 21, 31, 41, 51 (only impeller 31 is shown in Figure 2) housed within a compressor housing 22, 32, 42, 52. The compressor units take in air axially through respective openings 23, 33, 43, 53 (opening 43 not shown) and output compressed air through respective radial outlets 24, 34,

44, 54 (outlet 44 not shown) to an engine inlet air manifold (not shown) along suitable conduits (not shown).

The turbine 10 drives the compressor impellers 21, 31, 41, 51 by way of an arrangement of gears 60 housed within a gearbox casing 18, to which are mounted the compressor housings 22, 32, 42, 52. The turbine housing 19 may be integral with the gearbox casing 18 or separate but attached thereto. Various forms of the gear arrangement 60 are shown in Figure 3.

Turbine 10 is mounted on a shaft 16 which carries a pinion 17, while impellers 21, 31, 41, 51 are mounted on respective shafts 25, 35, 45, 55. In the embodiment shown in Figure 1, the compressors on opposite sides of a vertical line passing through the turbine shaft 14 have oppositely disposed radial outlets (see Figure 1), requiring either that differently configured impellers be employed for compressor units 20 and 30 on the one hand and units 40 and 50 on the other, the impellers being then driven in the same direction, or that similar impellers be used, but driven in contra-rotation. In the former case the gear arrangement shown in Figure 3(a) may be used which includes, in addition to the aforementioned turbine pinion 17, impeller pinions 26, 36, 46, and 56 mounted on respective impeller shafts, and intermediate pinions 61, 62, and 63. Pinions 17, 61 and 26 form a gear train for the compressor unit 20, pinions 17, 62 and 36 a gear train for the compressor unit 30, pinions 17, 62 and 46 a gear train for the compressor unit 40 and pinions 17, 63 and 56 a gear train for the compressor unit 50.

As an alternative to the gear arrangement shown in Figure 3(a) the configuration shown in Figure 3(b) may be employed. In this configuration the compressor pinions 26,

36, 46 and 56 mesh directly with the turbine pinion 17 instead of indirectly via the intermediate pinions featured in the previous realisation.

Where the impellers are required to rotate in different directions, the configuration of Figure 3(c) may be employed, in which the turbine pinion 17 drives the impeller pinions 46 and 56 through two intermediate pinions 64, 65, whereas impeller pinions 26, 36 are driven through only one, namely pinion 66. Now a clockwise rotation, say, of the turbine 10 will result in similarly clockwise rotation of pinions 26 and 36, but anticlockwise rotation of pinions 46 and 56.

Another way of avoiding the use of impeller blades of different sense while preserving the simplicity of uniform direction of rotation of the impeller shafts is to allow the radial outlets 44, 54 to face upwards instead of downwards on the same side of the compressor housing (see dotted outlet representation in Figure 1).

The gearing arrangements shown in the drawings are not exhaustive, but represent merely a few of the many possible configurations that may be employed to transfer the rotational movement of the turbine to the compressor impellers.

In the preferred embodiment of the invention one or more of the impellers are driven by the gear arrangement through a disconnection means in the form of a clutch arrangement, an example of which is shown very schematically as 37 in Figure 2. By this means the relevant impellers may be switched in or out in dependence on engine loading and charge-air requirements.

In a preferred embodiment of the invention the air outlets 24, 34, 44, 54 of the compressor units are connected to the engine air-inlet manifold in parallel, although it is also

within the ambit of the invention that they be connected in series. In the latter case a multistage compressor arrangement is created by feeding the air outlet of one compressor unit directly to the air inlet of another. Alternatively, compression may be performed in both series and parallel, with two of the compressor units, for example, being connected in series and feeding the engine air-inlet manifold along with the remaining two compressor units in parallel. Such a configuration is shown in Figure 4. It is also possible to use fewer than or more than the four compressor units shown in the diagrams, according to individual engine requirements.

Figure 5 illustrates the use of a double impeller 31 instead of the single impeller shown in Figure 2. This "back-to-back" impeller arrangement provides twice the output of a single impeller and can therefore enable a reduction in compressor units to be made for any particular application.

The preferred embodiment of the invention also includes the use of a hydraulic pump attachment or electric motor/generator 70 geared to the turbine in a manner already described in connection with the compressor units. Such a device is shown in Figure 6 and acts either to supplement the turbocharger output, for example during times of turbo-lag when the engine is being accelerated, or to take up excess exhaust-gas energy when the engine is running at optimum. Such excess power may be used for a variety of purposes, e.g. where attachment 70 is an electric motor/generator operating in generator mode, electricity can be produced for use on or off the turbine plant.

The use of a plurality of compressor impellers driven from just the one turbine in accordance with the invention results in a considerable saving in material outlay compared

with the use of a single large impeller. In general, doubling the diameter of an impeller gives a fourfold increase in airflow, but results in approximately eight times the volume of material used. Thus, four impellers of a particular size could generate the same airflow as a single impeller twice that size, but would require in total only half the amount of material of the larger impeller. Where in both cases high-grade impeller material is employed, this can reduce outlay very significantly. The applicants estimate that a turbocharger utilising the principles outlined above can cost in the region of 70% of the cost of an equivalent rated turbocharger utilising a single 2-ton impeller, where the titanium impeller represents 55% of the total turbocharger cost. Even further savings can be realised where the required size of a smaller impeller as used in the present invention is such that lower-grade material can be used due to the lower stresses experienced by the impeller.

A further feature of the present invention is that, since the turbine is mounted on its own shaft separate from any of the compressor impellers, the size restrictions, and in particular length limitations, that apply to the usual turbine-impeller pair in which both items share the same shaft are not applicable here, so that the design of the turbine diffuser and the remaining exhaust components can be optimised to avoid the static pressure loss normally resulting from a compromise design. This optimised design takes the form of an axial-flow diffuser of sufficient length used in combination with an axial-flow exhaust, a situation which is to be contrasted with the usual compromise design of a shortened diffuser leading to a radially configured exhaust outlet.

This latter feature can help to maintain turbocharger efficiency in the invention. Thus, although gearbox losses are experienced in the turbocharger arrangement according

to the invention, and a further smaller reduction in efficiency may be experienced due to the use of smaller impellers (the "Reynolds Number" effect), this is at least compensated by the use of an optimised turbine diffuser and casing arrangement.

CLAIMS

1. Turbocharger arrangement comprising a turbine mounted on a turbine shaft having a first axis of rotation and a plurality of compressors mounted on respective compressor shafts having respective further axes of rotation, said first and further axes being separate axes, said turbine being in driving relationship to said compressors through an arrangement of gears.

2. Turbocharger arrangement as claimed in Claim 1, in which said arrangement of gears comprises for each compressor shaft a gear train connecting said compressor shaft with said turbine shaft.

3. Turbocharger arrangement as claimed in Claim 2, in which said gear train comprises a driving pinion mounted on said turbine shaft, a driven pinion mounted on said compressor shaft, and at least one intermediate pinion connecting said driving pinion with said driven pinion.

4. Turbocharger arrangement as claimed in Claim 1, in which said arrangement of gears comprises a driving pinion mounted on said turbine shaft and a plurality of driven pinions mounted on respective said compressor shafts, said driven pinions engaging with said driving pinion around a circumference thereof.

5. Turbocharger arrangement as claimed in any one of the preceding claims, in which said compressors are connected in parallel to an air inlet of an engine with which the turbocharger is associated.

6. Turbocharger arrangement as claimed in any one of Claims 1 to 4, in which said compressors are connected in series to an air inlet of an engine with which the turbocharger is associated.

7. Turbocharger arrangement as claimed in any one of Claims 1 to 4, in which said compressors are connected in a series-parallel arrangement to an air inlet of an engine with which the turbocharger is associated.

8. Turbocharger arrangement as claimed in any one of Claims 5 to 7, in which at least one of said compressors is driven from said turbine by way of a disconnection means thereby to enable drive to said at least one of said compressors to be selectively disconnected in response to charge air requirements of said device.

9. Turbocharger arrangement as claimed in any one of the preceding claims, in which a power source and/or sink can be brought into engagement with said arrangement of gears thereby to supplement power supplied by, and/or to absorb excess power from, said turbine.

10. Turbocharger arrangement as claimed in Claim 9, in which said power source and/or sink is an hydraulic pump or a rotating electrical machine.

11. Turbocharger arrangement as claimed in any one of the preceding claims, in which said turbine is an axial-flow turbine and in which an exhaust-gas diffuser associated with said turbine has a longitudinal axis substantially the same as said first axis of rotation, said diffuser in use discharging to an axial-flow exhaust outlet.

12. Turbocharger arrangement substantially as shown in, and/or as hereinbefore described with reference to, Figures 1 to 6 of the drawings.

The Patent Office

12

Application No:	GB 9701507.7	**Examiner:**	C B VOSPER
Claims searched:	1-12	**Date of search:**	21 March 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): F1C(CBA,CBC,CBE,CBG); F1G(GPA,GPC,GPX); F1Q(QCA,QDD)

Int Cl (Ed.6): F02C 6/00,6/04,6/10,6/12; F02B 37/00,37/007,37/013; F04D 25/00,25/02,25/04,25/08,25/16

Other: ONLINE WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	GB0992651	LICENTIA (page 2, lines 4-12)	4
X:Y	GB0698783	INCONEX (fig.1)	1-3,5,11 : 4
X:Y	GB0696191	SULZER (whole document)	1-3,6,9 : 4
X:Y	EP0620363A1	PRAXAIR (fig. 1; col. 4, line 55 - col. 5, line 56)	1-3,6,9,10 :4
X:Y	EP0555948A1	MANNESMANN (whole document)	1-3 at least : 4
X:Y	EP0440902A1	DEUTSCHE BABCOCK (whole document)(Equivalent = US5154571)	1-3 at least : 4
X:Y	WPI Abstract Accession No. N92-279667 of DE4113247 (BAYM) (see last four lines in particular)		1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.